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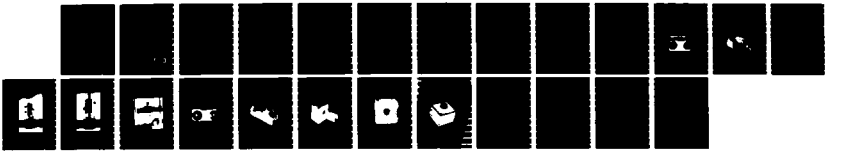

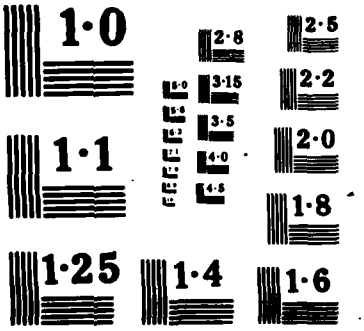
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Structures Technical Memorandum 433

STRENGTH TESTS ON FASTENERS IN GRP VINYL FOAM SANDWICH

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STRENGTH TESTS ON FASTENERS IN GRP-VINYL FOAM SANDWICH

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R. BAILEY and B. QUINN

SUMMARY

A series of tests was made to establish the strength and behaviour of metal fastener attachments to GRP-vinyl foam sandwich structure. The tests were made to provide design data for the proposed Royal Australian Navy catamaran minehunter.

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CONTENTS

1. INTRODUCTION

Tests have been made to establish the strength and behaviour of sandwich construction made from glass reinforced plastic (GRP) and rigid vinyl foam core to provide design data for the Royal Australian Navy catamaran minehunter (Ref. 1). Further tests were required to establish the strengths of various types of metal fastener attachments proposed for use with the sandwich construction.

2. DESCRIPTION OF SPECIMENS

The sandwich construction comprised a 60 mm thick rigid vinyl foam core ("Klegecell" H130, nominal density 130 kg/m^3) sandwiched between skins of glass reinforced plastic made up from seven layers of chopped strand mat (300 gm/m^2) and seven layers of woven rovings (600 gm/m^2). The chopped strand mat and woven rovings were laid up in alternate layers so that the woven rovings formed the outer skin (see Figure 1).

Three sets of specimens were tested as follows:

i. Six specimens for shear testing.

ii. Seven specimens for "pull-out" testing.

iii. Six specimens for "pull-through" testing.

Each specimen for the shear tests comprised a sandwich section 350 mm x 120 mm fitted with two wooden spacers through the section. Two circular wooden pads were bonded to the GRP skins at the ends of each spacer and 12 mm diameter holes were provided for bolts through each pad/spacer assembly as shown in Figures 2 and 3.

For the pull-out specimens a sandwich section of 100 mm x 100 mm was used and self tapping screws, of Buildex type 17, 14 gauge x 40 mm long were located in the centre of each specimen. Pilot holes of various diameters were used for the self tapping screws in order to determine the effects of pilot hole diameter on the pull-out strength of the fastener (see Figure 4).

The sandwich section for the pull-through specimens was also 100 mm x 100 mm and provided with a 25 mm diameter wooden spacer through the sandwich and 12 mm thick wooden pads at each end of the spacer bonded to the skins as shown in Fig. 5. A 12 mm diameter bolt was used to apply the load to the specimens.

3. METHOD OF TESTING

All the specimens were tested in the Tate Emery 260 kN universal testing machine.

3.1 Shear Specimens

Each test specimen was mounted in the testing machine and the load applied through steel links as illustrated in Figs 6 and 7. Load was applied in increments and

dial gauge readings recorded at each increment. The load was applied until failure occurred.

3.2 Pull-Out Specimens

Each test specimen was mounted in the testing machine using a saddle and ring to apply the load to the self tapping screw (see Figure 4). The saddle also ensured that only the threaded portion of the screw was screwed into the skin of the specimen. The screws were then torqued into position.

Vertical load was then applied to the specimen until failure occurred.

3.3 Pull Through Specimens

Each specimen was mounted in the testing machine as shown in Fig. 8. A dial gauge was mounted on the lower cross head of the testing machine to measure the deflection of the specimen. Load was applied through a bolt through the specimen attached to the lower crosshead of the testing machine. The load was applied until failure occurred.

4. RESULTS OF TESTS

4.1 Shear Specimens

The maximum loads achieved for the six specimens varied between 20,000 N (Specimen No 5) and 35,500 N (Specimen No 6). With the exception of Specimen No 1 all failures were timber failure and were affected by the orientation of the grain to the loading axis. While the grain orientation was random it appeared that those specimens with grain orientation at or near 90° to the load axis achieved a higher failing load, eg. Specimen No 6, Fig. 10. Specimen No 1 was the exception where the bolt failed at 26,000 N as shown in Fig. 9.

The results of the tests are shown in the following table.

TABLE 1

SPECIMEN NO	MAXIMUM LOAD (N)	COMMENTS
1	26,000	Bolt failure + timber failure
2	32,000	Timber failure
3	30,000	Timber failure
4	30,000	Timber failure
5	20,000	Timber failure
6	35,500	Timber failure

4.2 Pull-Out Specimens

The maximum pull-out loads achieved were for Specimen Nos 3 and 4 where the failing loads were 7600 N and 7300 N respectively. This is attributed to these two fasteners being installed with the smallest pilot hole diameter viz 4.5 mm. The magnitude of the pull-out load is directly associated with the pilot hole diameter as shown in the accompanying table of test results:

TABLE II

SPECIMEN NO	PULL-OUT LOAD (N)	SCREW TORQUE (Nm)	PILOT HOLE DIAMETER (mm)
1	6350	3.39	5.0
2	6600	3.39	5.0
3	7600	6.78	4.5
4	7300	6.78	4.5
5	5380	6.78	5.2
6	5600	6.78	5.2
7	6850	6.78	5.0
8	7100	6.78	5.0

(See Figures 11 and 12 for details of failure).

4.3 Pull-Through Specimens

The failing loads for these six specimens varied between 28,050 N to 35,200 N. All specimens failed by compression of the PVC foam as shown in Fig. 13. Failing loads and deflections are given in the following table:

TABLE III

SPECIMEN NO	FAILING LOAD (N)	DEFLECTION (mm)
1	35,200	3.40
2	30,300	3.82
3	28,050	3.86
4	32,000	3.47
5	30,000	3.64
6	30,950	3.67

5. CONCLUSION

These tests have provided design data for metal fasteners in GRP-vinyl foam sandwich for the proposed RAN catamaran minehunter.

REFERENCE

1. Townshend, P.H. Static Bending Tests of GRP-Vinyl Foam Sandwich Beams. ARL STRUCT TECH MEMO 324, October 1980.

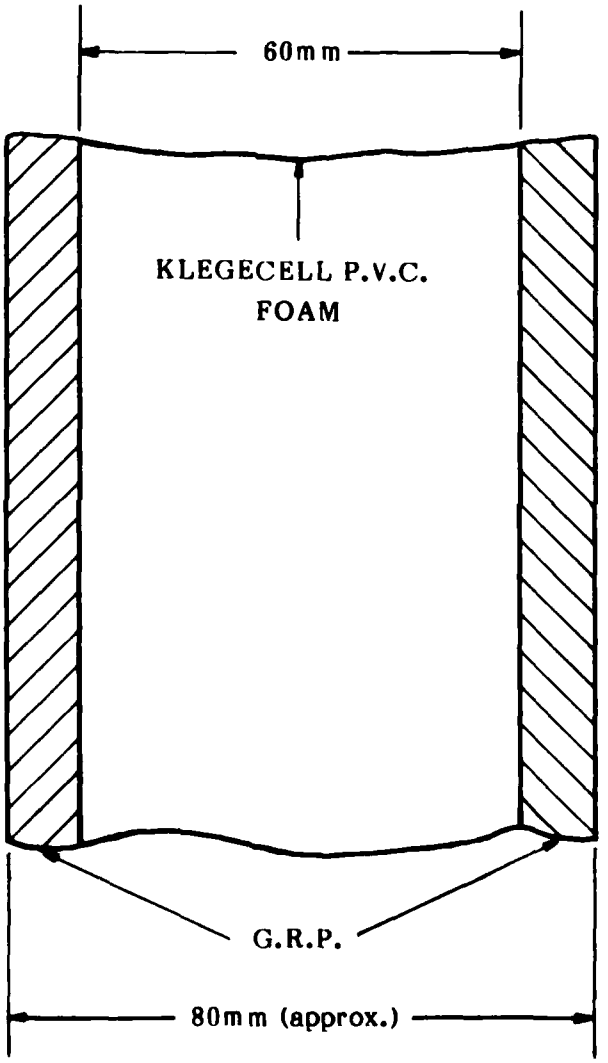

FIG. 1 CONSTRUCTION OF GRP-FOAM SANDWICH

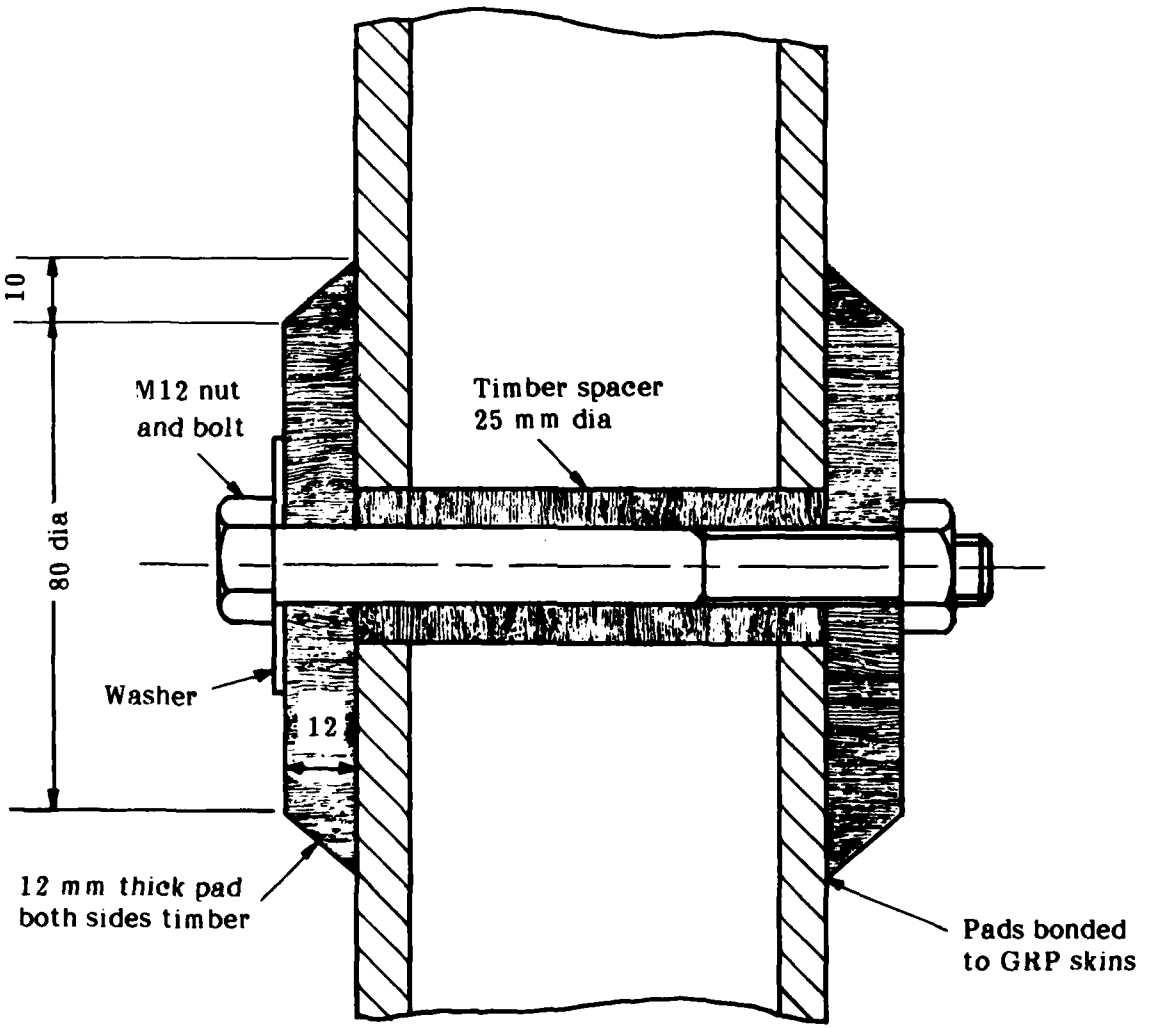

FIG. 2 CONSTRUCTION OF SHEAR TEST SPECIMENS WITH WOODEN SPACER THROUGH THE SPECIMEN AND WOODEN PADS BONDED TO GRP SKIN

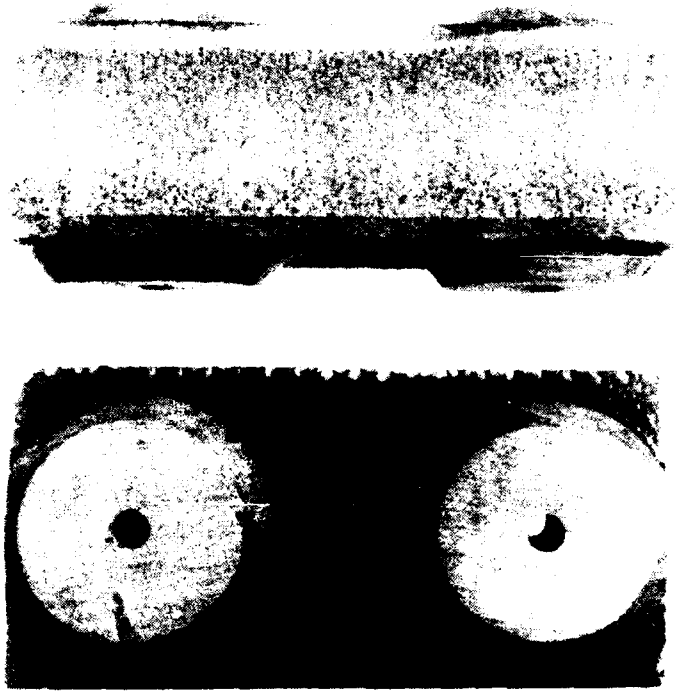

FIG. 3 SIDE AND TOP VIEW OF THE SHEAR TEST SPECIMEN SHOWING TYPICAL CONSTRUCTION

FIG. 4 VIEW OF PULL-OUT SPECIMEN SHOWING TEST RING, SADDLE AND 'BUILDEX' TYPE SELF-TAPPING SCREW

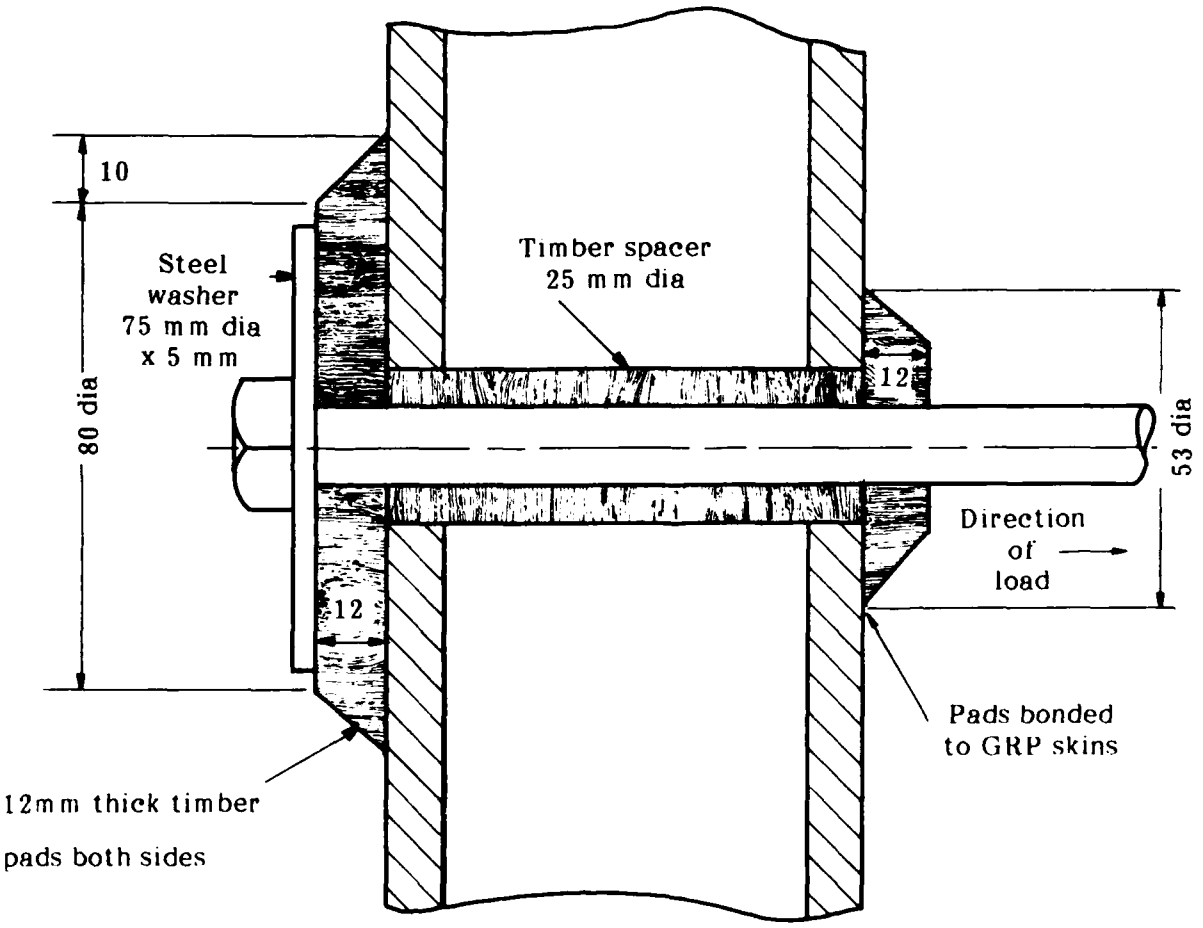

FIG. 5 TYPICAL CONSTRUCTION OF A PULL-THROUGH SPECIMEN WITH WOODED SPACER THROUGH THE SPECIMEN AND WOODEN PADS BONDED TO THE GRP SKIN

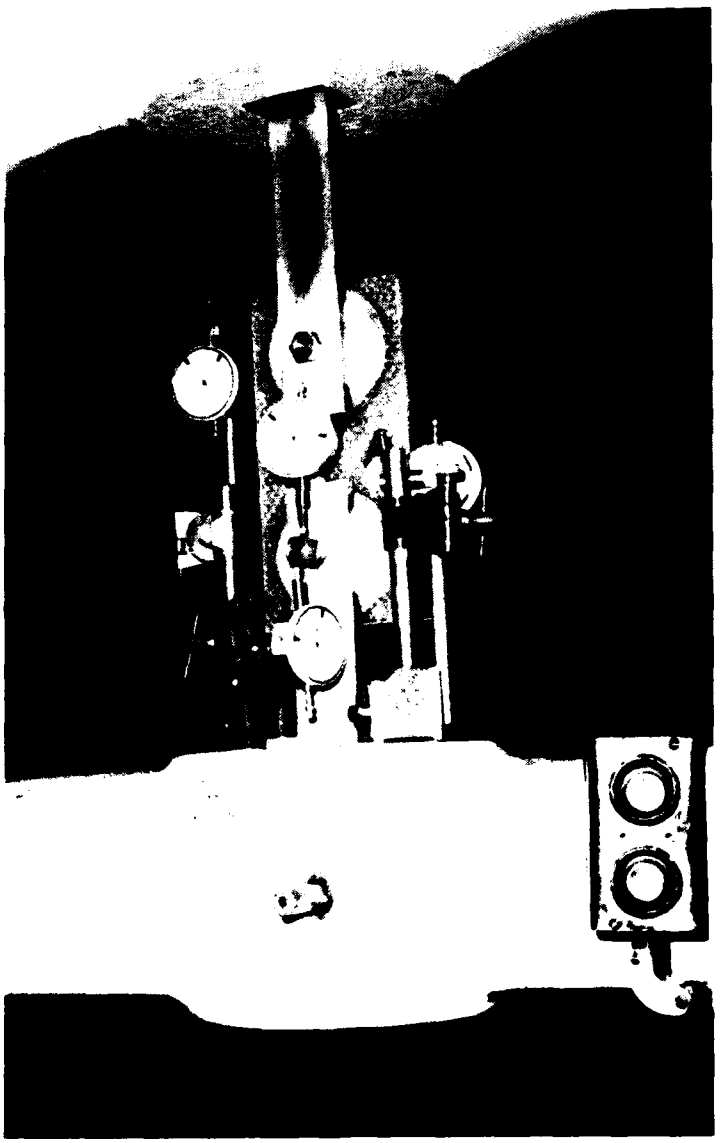

FIG. 6 FRONT VIEW OF TYPICAL SET UP FOR A SHEAR TEST SPECIMEN SHOWING THE POSITION OF DIAL GAUGES ON THE SPECIMEN

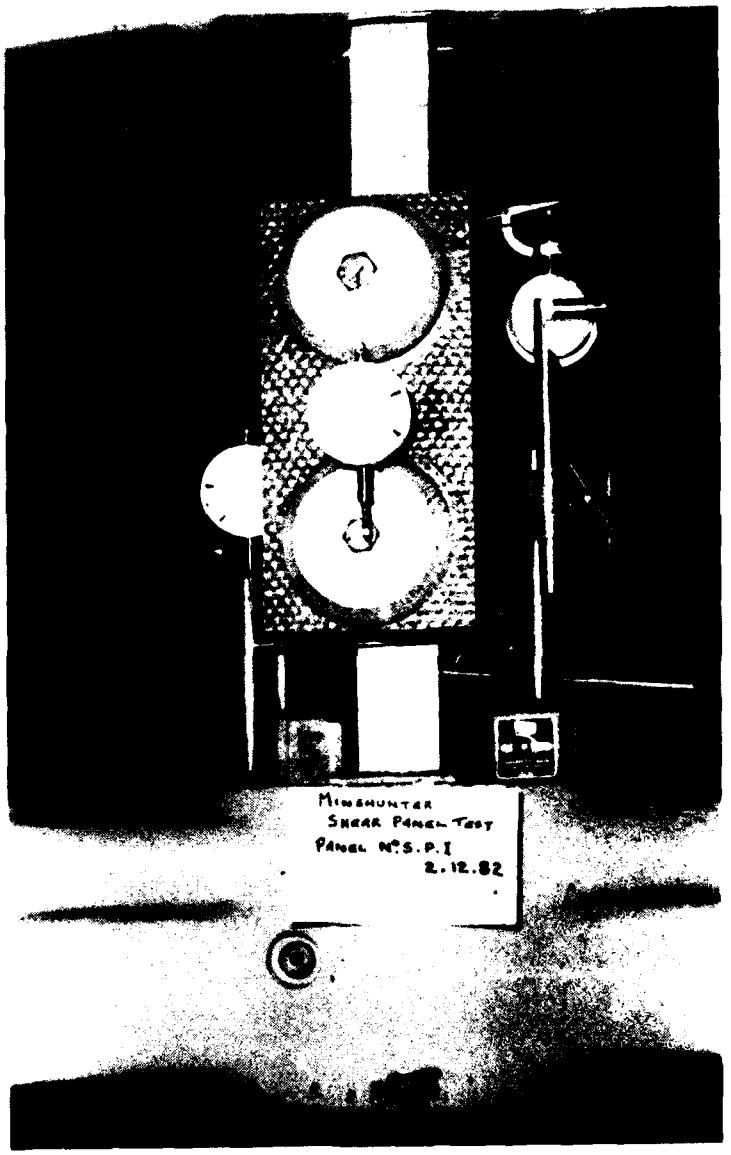

FIG. 7 REAR VIEW OF TYPICAL SET UP FOR SHEAR TEST SPECIMEN SHOWING THE POSITION OF DIAL GAUGES ON THE SPECIMEN

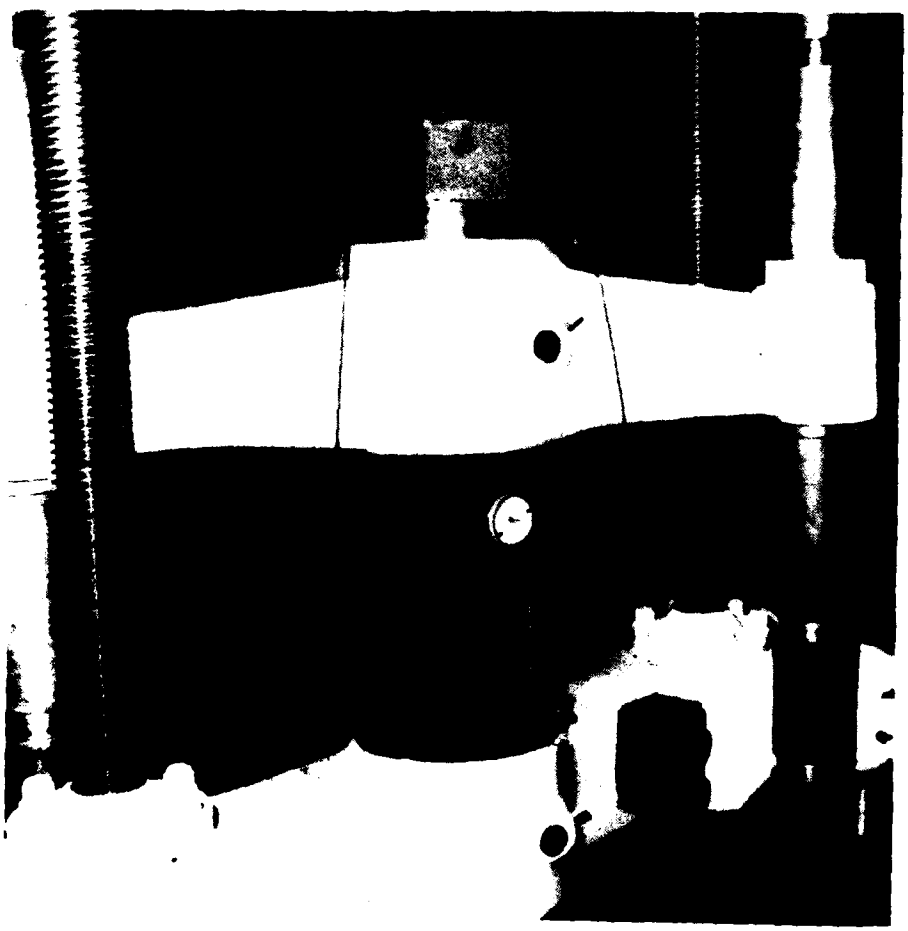

FIG. 8 VIEW OF TYPICAL SET UP FOR PULL-THROUGH SPECIMENS SHOWING POSITION OF THE DIAL GAUGE ON THE LOWER CROSS-HEAD

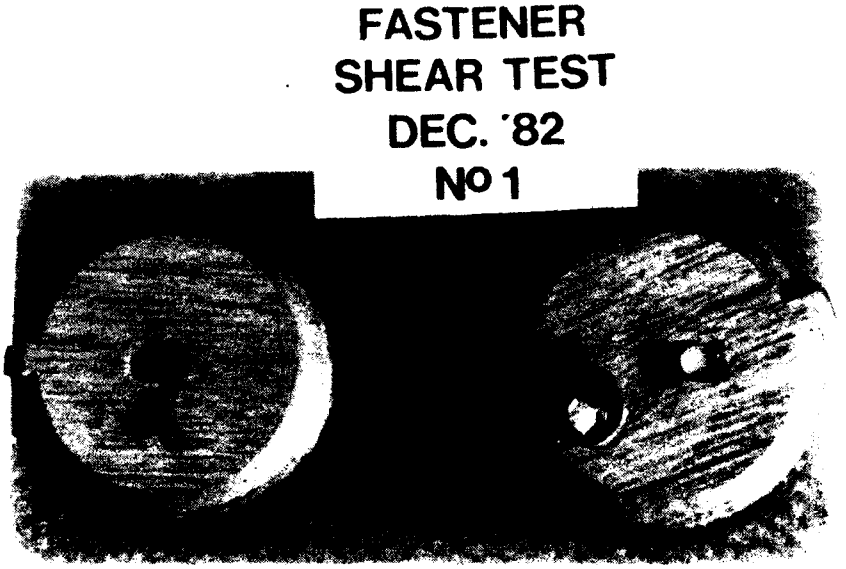

FIG. 9 TOP VIEW OF SHEAR TEST SPECIMEN SHOWING FAILURE OF THE BOLT AND THE WOODEN PADS ALONG THE GRAIN

FIG. 10 VIEW OF TEST SPECIMEN SHOWING FAILURE OF A WOODEN PAD

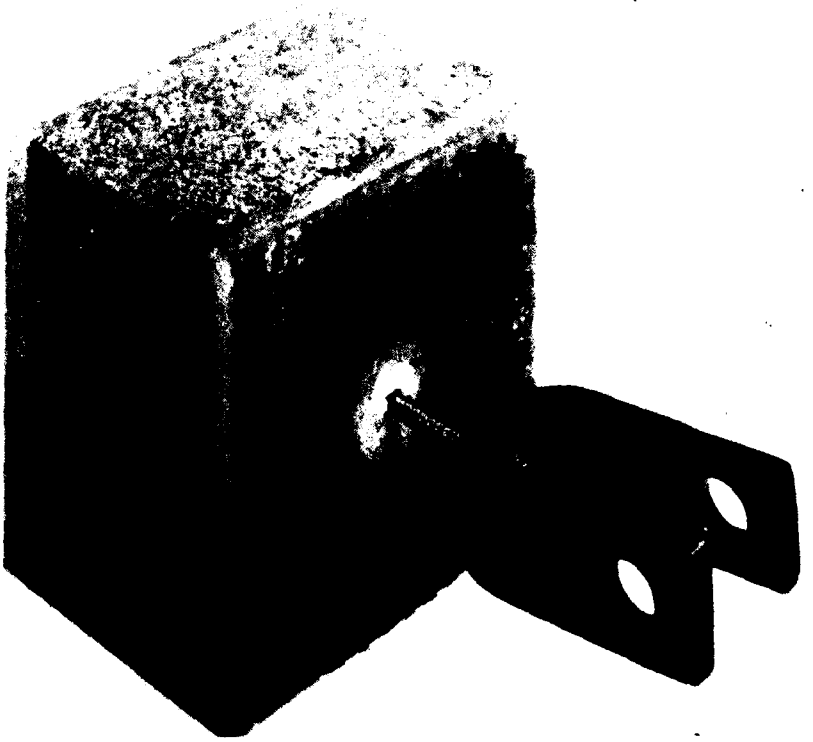

FIG. 11 VIEW SHOWING THE TYPICAL FAILURE OF A PULL-OUT SPECIMEN

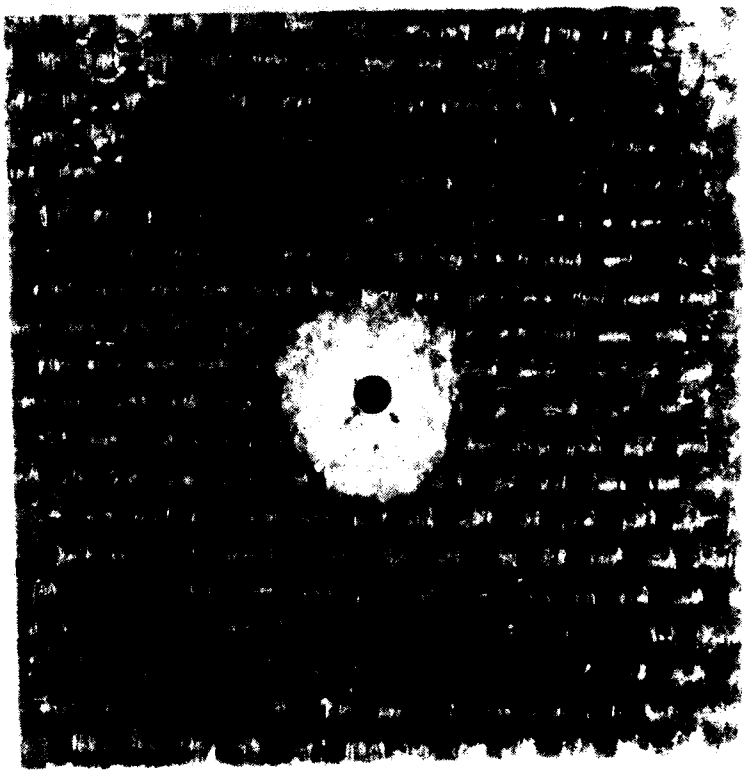

FIG. 12 VIEW SHOWING THE LOCAL DAMAGE TO THE GRP SKIN AFTER THE PULL-OUT TEST

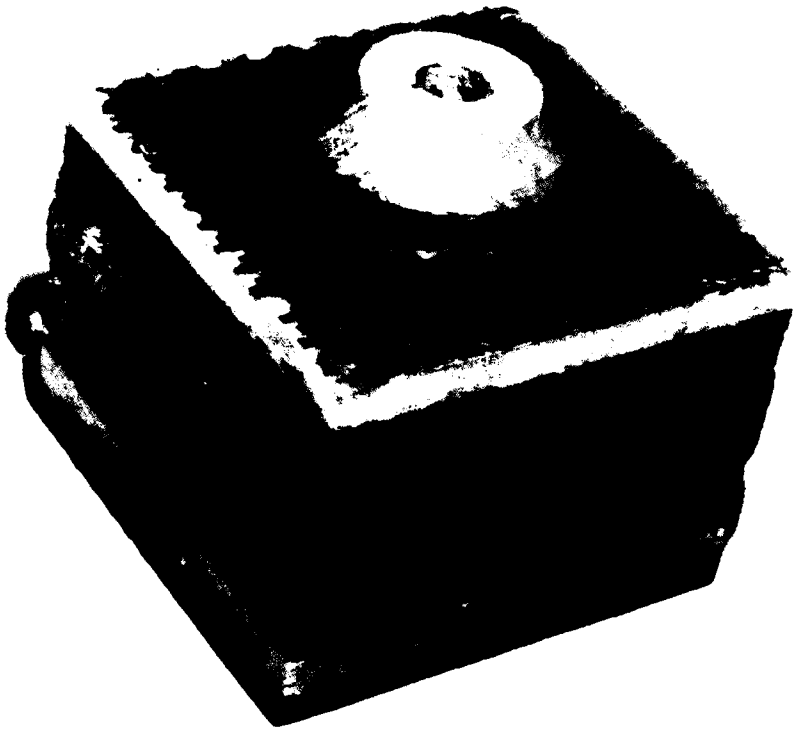

FIG. 13 PULL-THROUGH SPECIMEN SHOWING
OF PVC FOAM

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Sandwich laminates		
Reinforced plastics		

18. Abstract

A series of tests were made to establish the strength and behaviour of metal fastener attachments to GRP-vinyl foam sandwich structures. The tests were made to provide design data for the proposed Royal Australian Navy catamaran minehunter.

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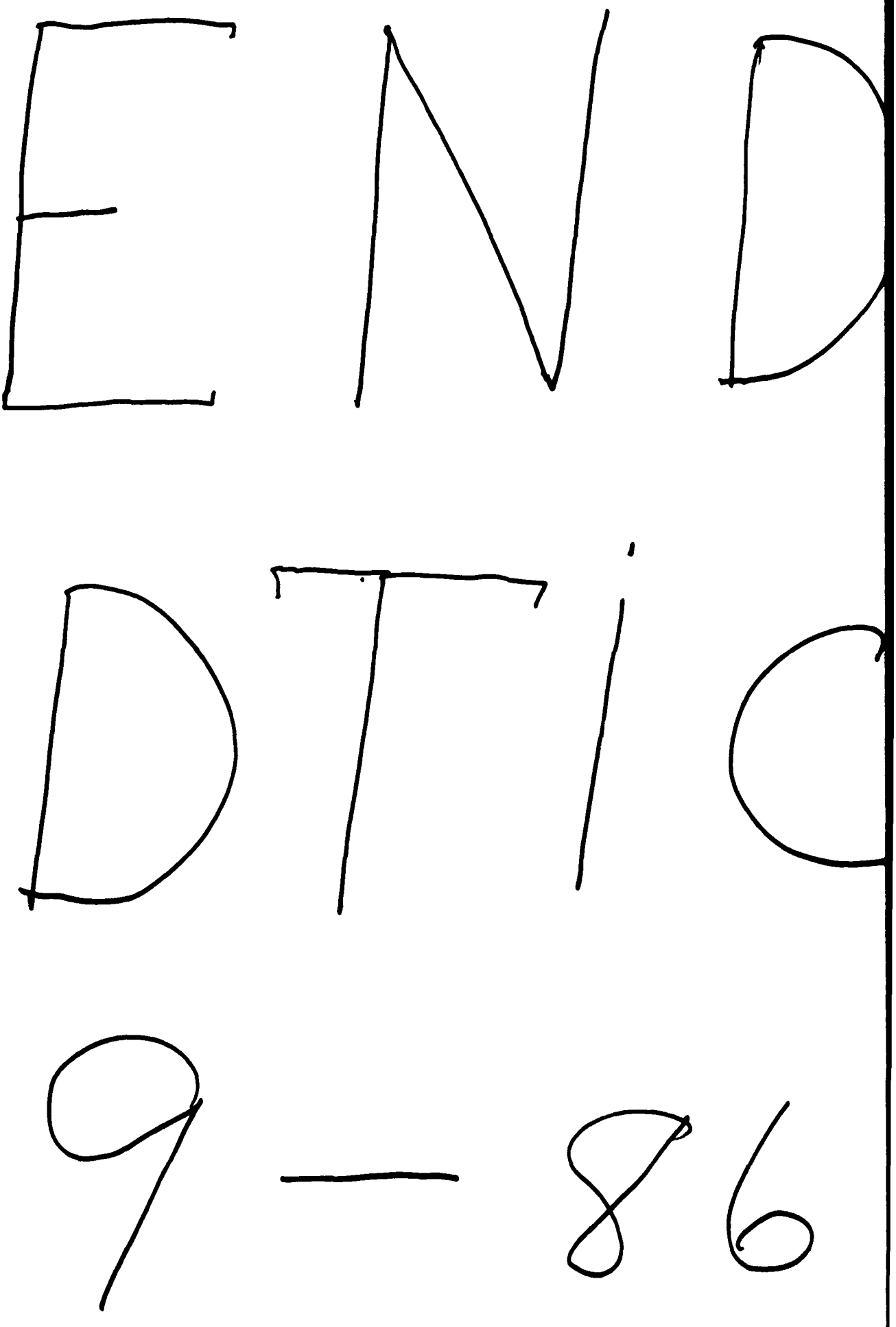
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